Operational Seasonal Forecasting: ENSO Examples

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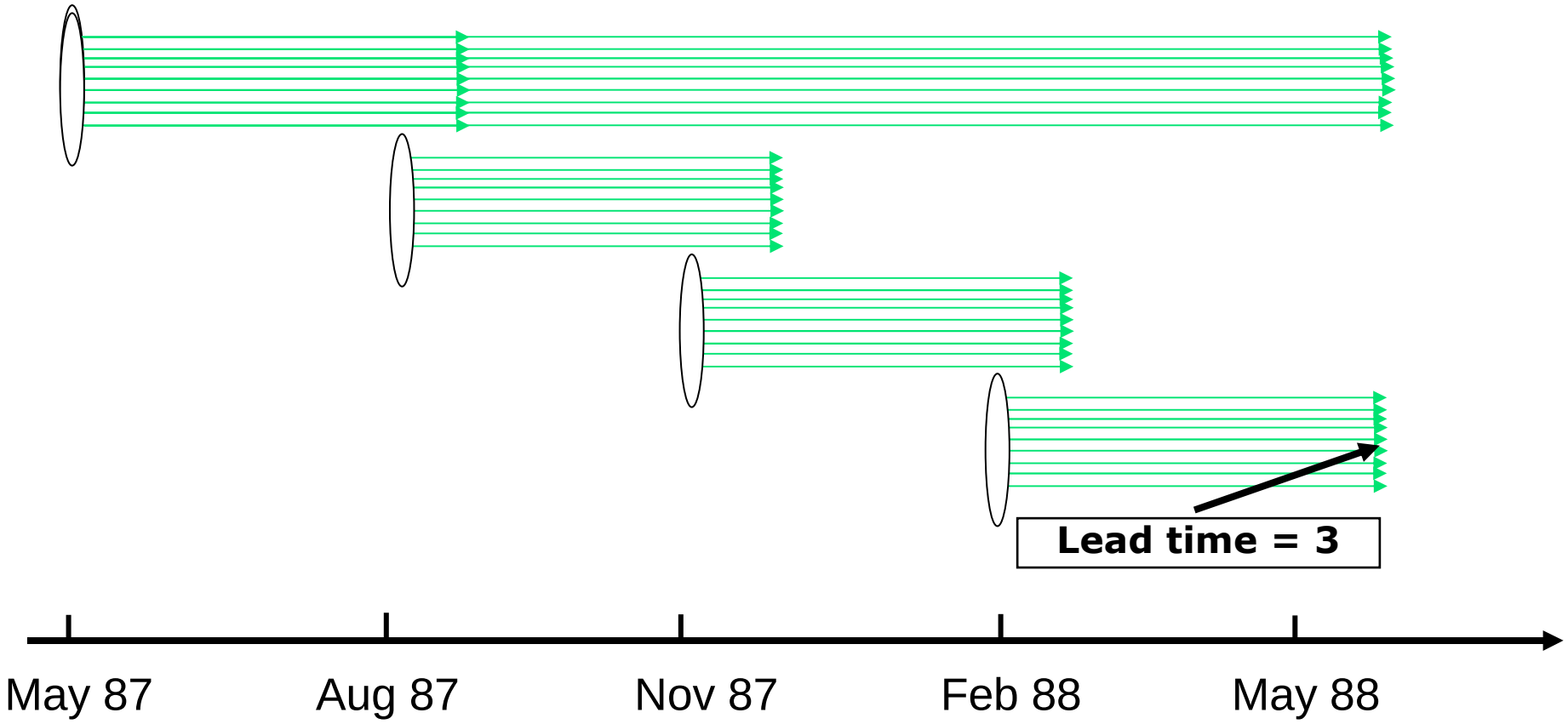
Ensemble climate forecast systems

Assume an ensemble forecast system with coupled initialized GCMs



Seasonal forecast experimental setup

- Two forecast systems: System 3 (IFS/HOPE) and EC-Earth v2.2 (IFS/NEMO)
- Initial conditions: ERA40/ERAInt atmosphere and land, ORA-S3 and NEMOVAR-COMBINE ocean, DFS4.3 sea ice
- Five-member ensemble hindcasts up to 7 months
- Ensemble from five-member ocean analysis and atmospheric perturbations (singular vectors, plus SST perturbations in System 3) added to each member
- Initial conditions valid for 0 GMT on the 1st of a month
- Four start dates per year: Feb, May, Aug and Nov.
- Forecast period 1981-2005

Seasonal predictions: mean bias

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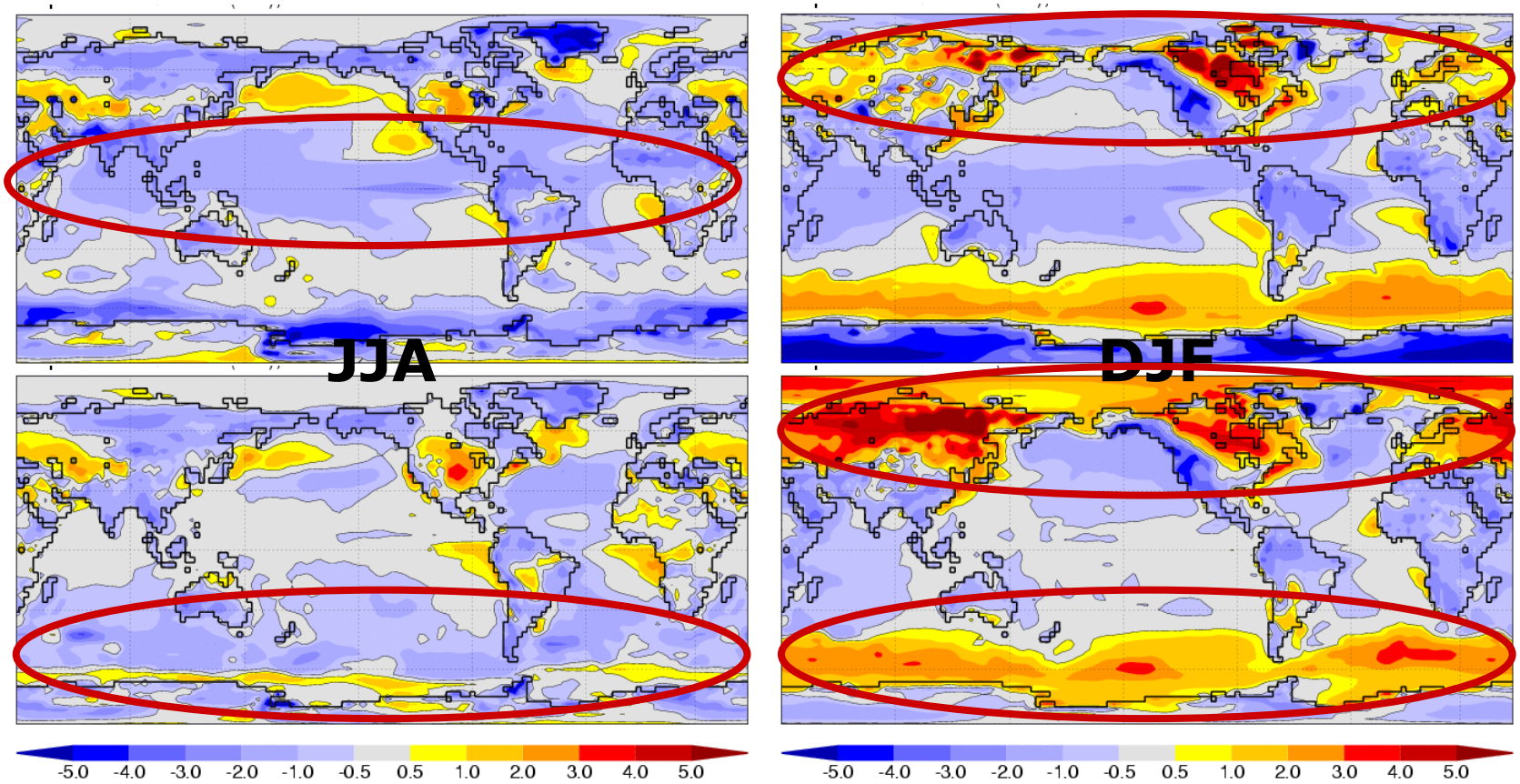
Bias of 2-4 month near-surface air temperature re-forecasts wrt ERA40/Int over 1976-2005.

EC-Earth

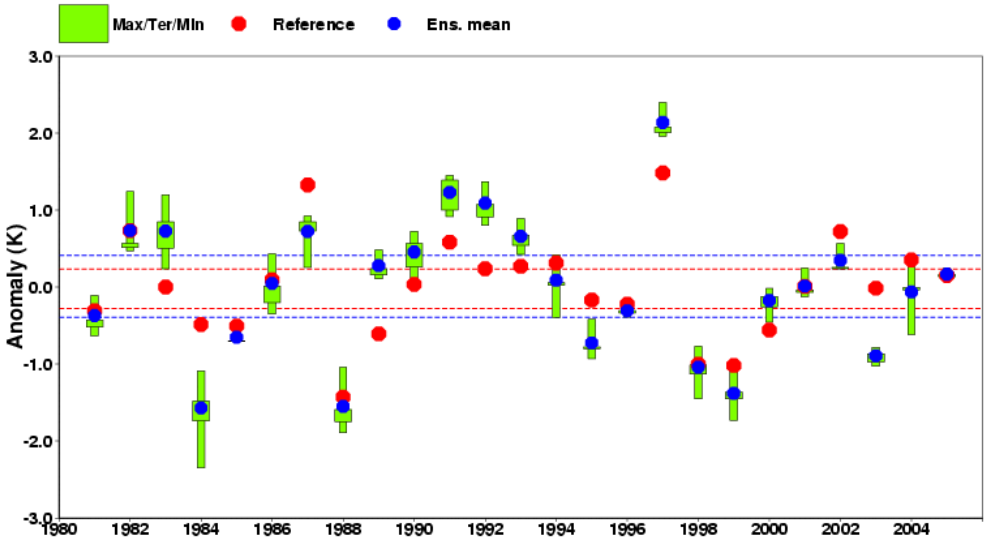
System 3



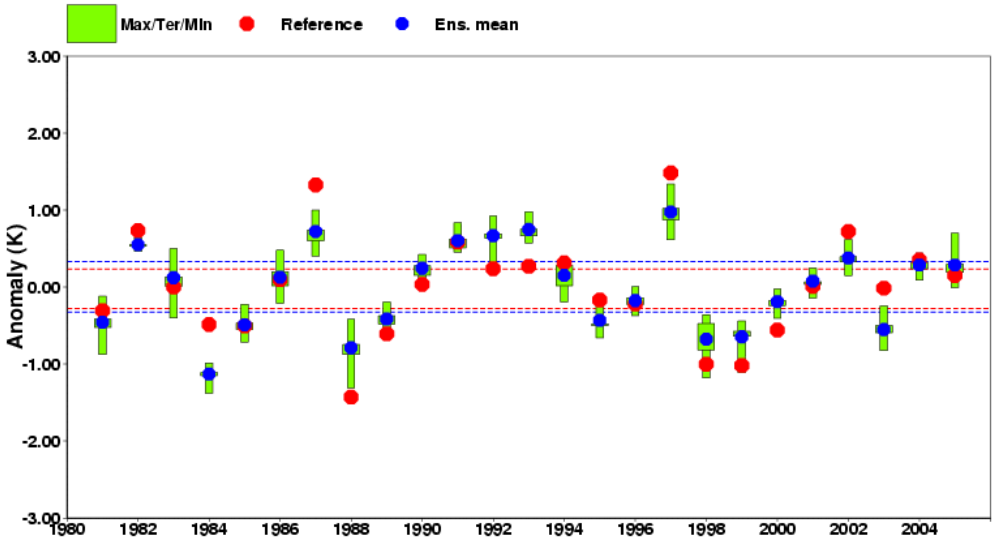
Seasonal predictions: ENSO

Niño3.4 time series for ERA40/Int (red dots), ensemble range (green box-and-whisker) and ensemble mean (blue dots) 2-4 month (JJA) re-forecasts over 1981-2005.

EC-Earth
Ratio sd: 1.34
Corr: 0.82
RPSSd: 0.48



System 3
Ratio sd: 0.84
Corr: 0.86
RPSSd: 0.68



Skill

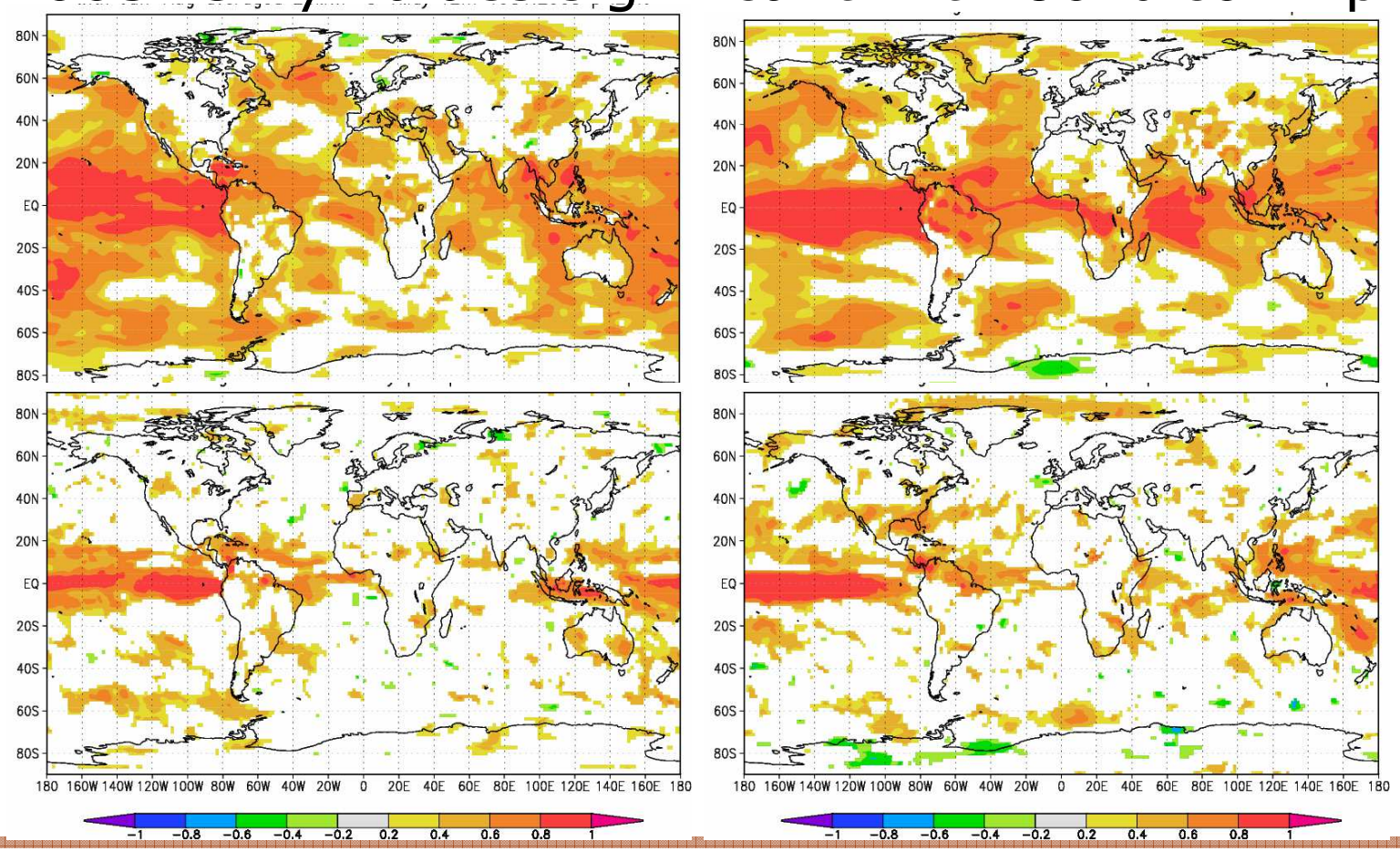
Correlation of System 3 seasonal forecasts of temperature (top) and precipitation (bottom) wrt GHCN and GPCC over 1981-2005. Only values significant with 80% conf. plotted.

JJA T2m

DJF T2m

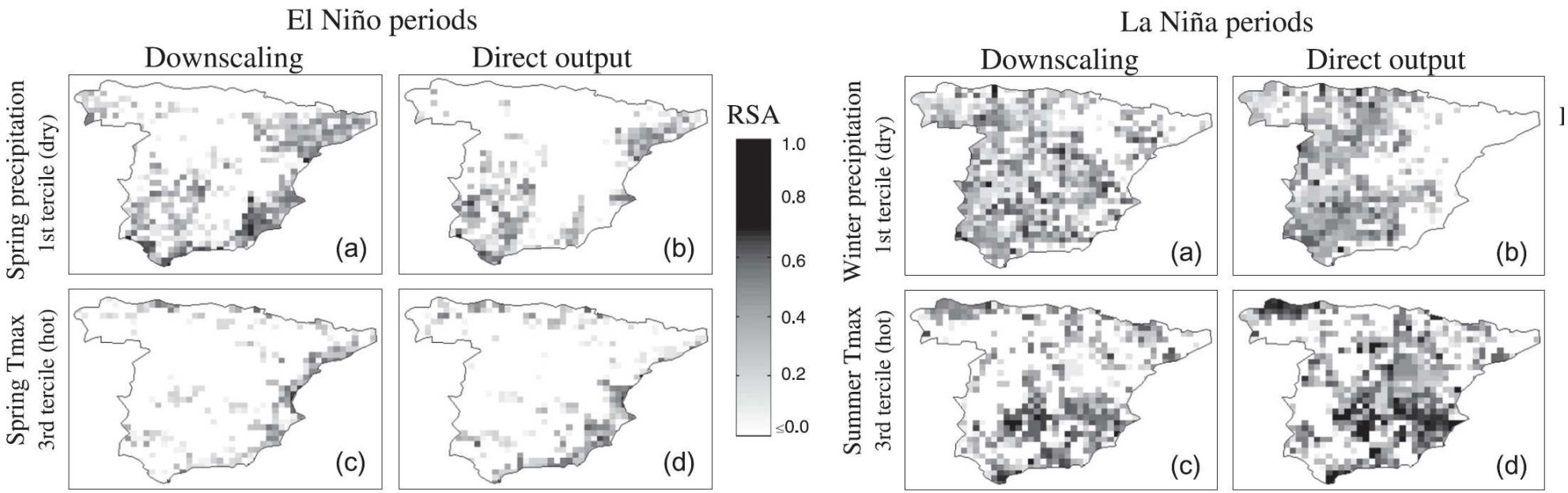
JJA Prec

DJF Prec



Extra-tropical links

ROC area of the (left column) statistically downscaled and (right column) original DEMETER seasonal predictions for several events where the years verified are segregated depending on the ENSO phase. Only values statistically significant with 90% confidence level are shown.



Frías et al. (2010)

Annual predictions: examples

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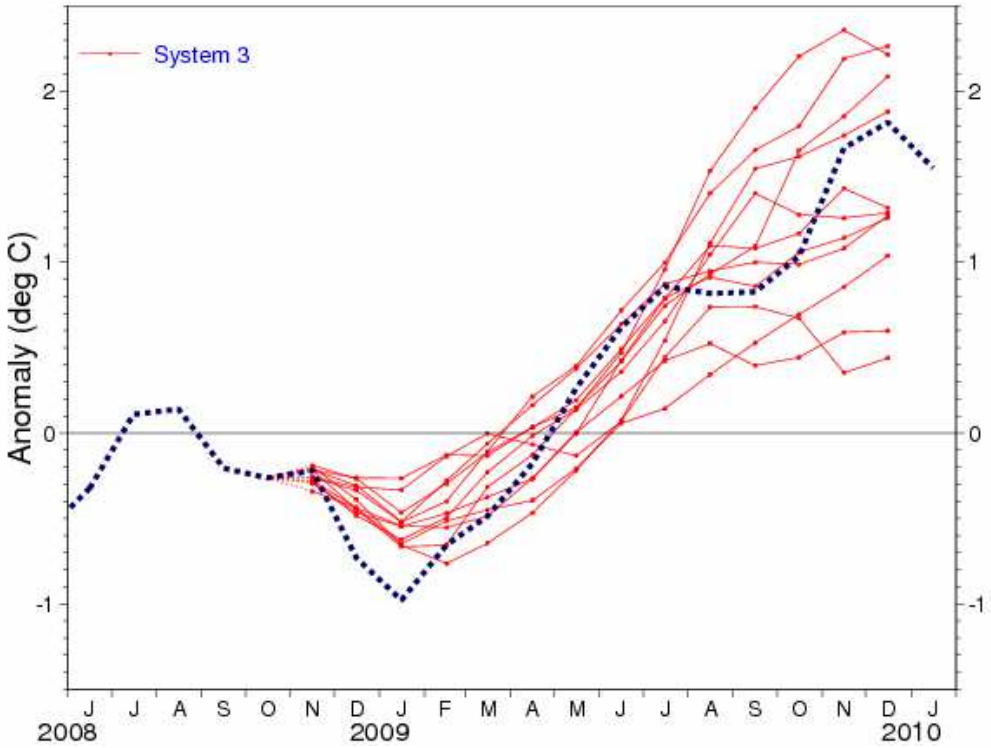
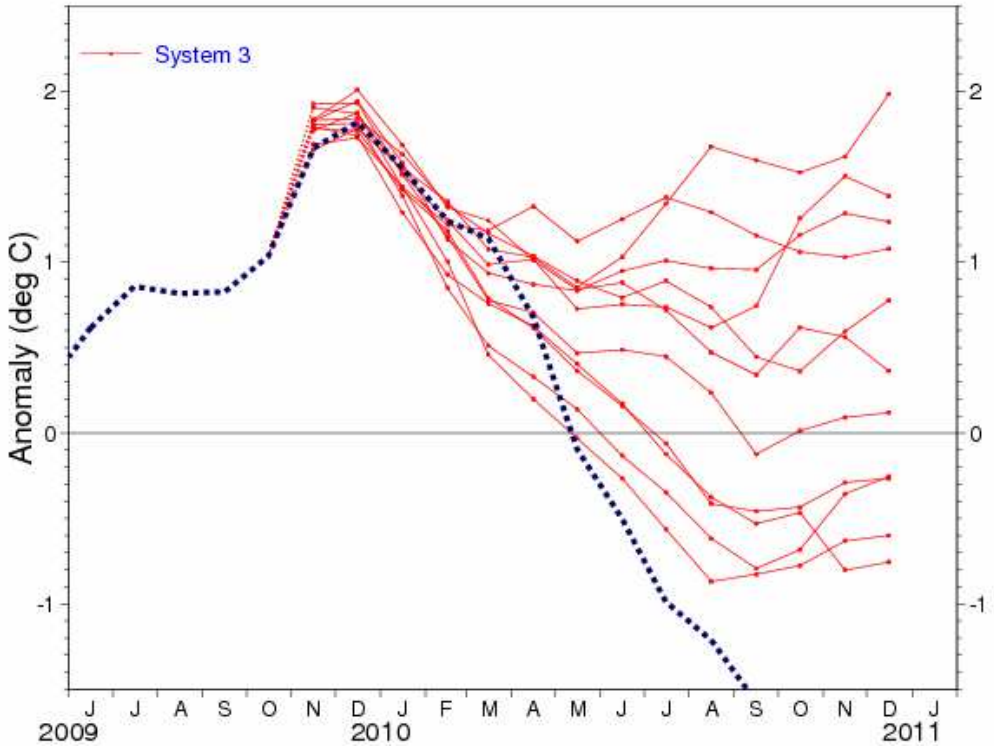
System 3 annual Niño3.4 sea surface temperature forecasts (red lines) and observations (blue line).

Nov 2008 start date

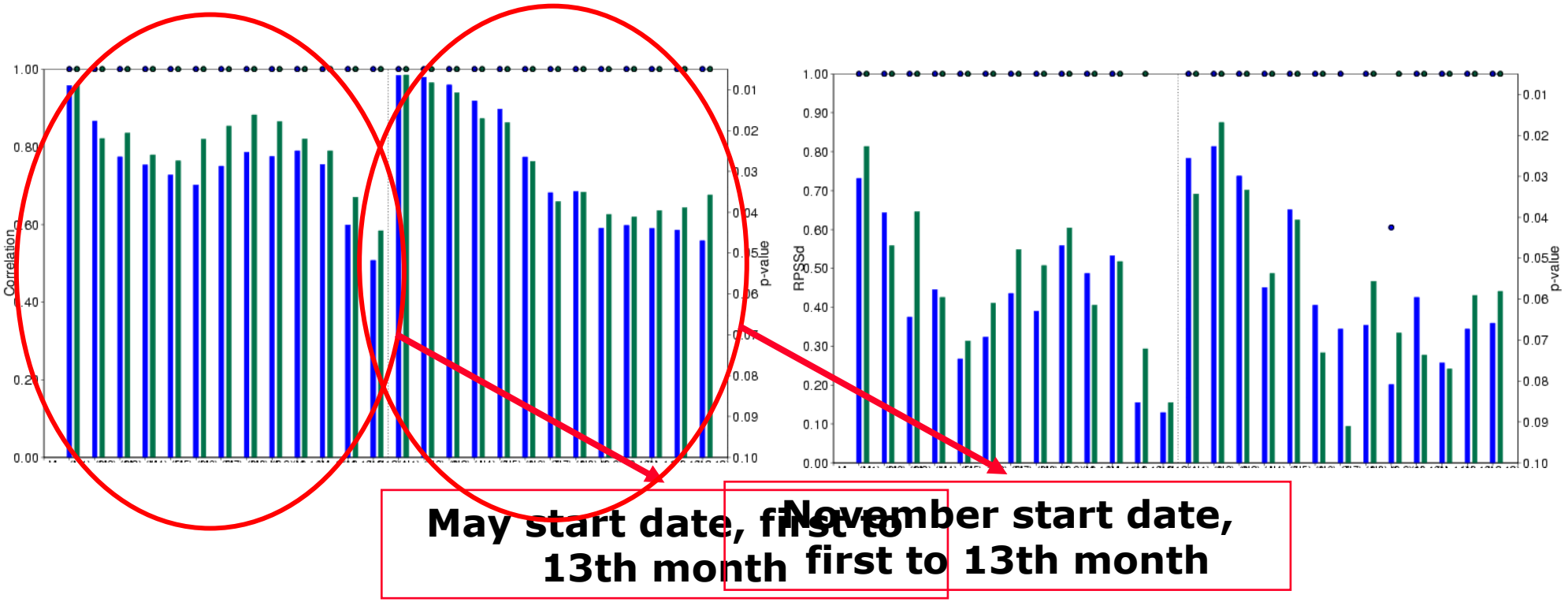


Nov 2009 start date



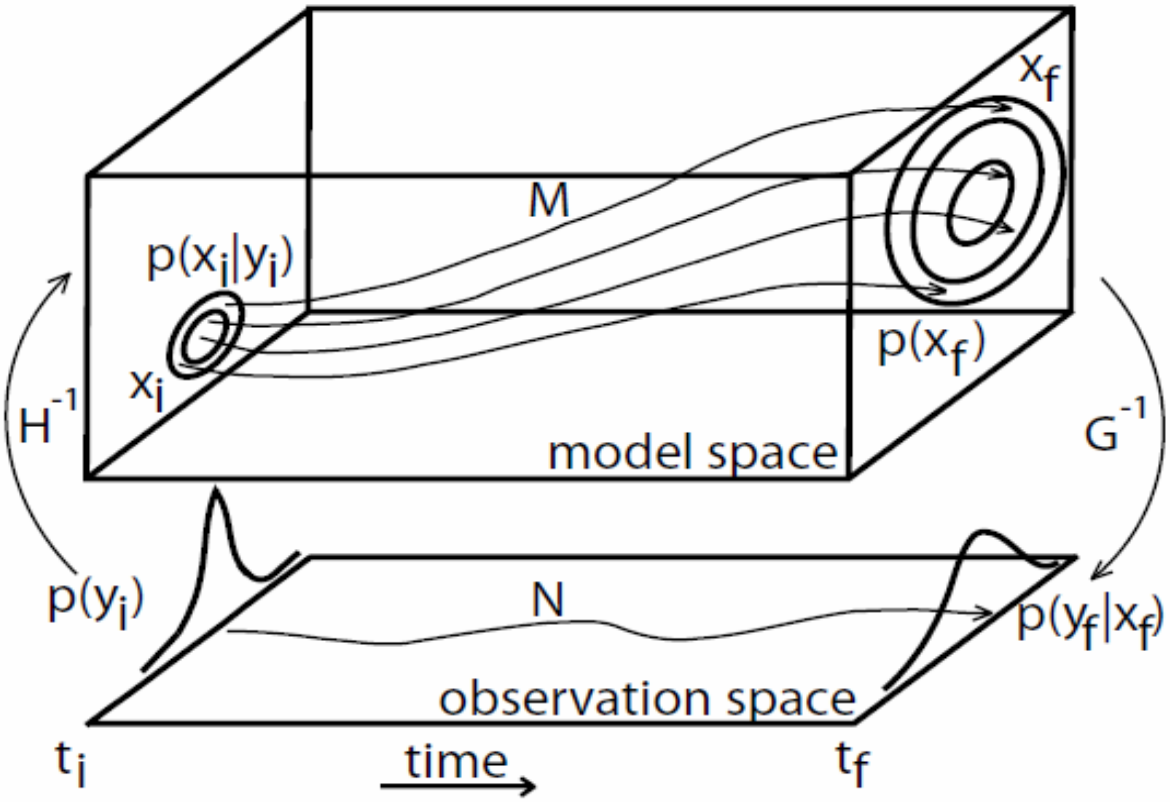
Annual predictions: ENSO

Niño3.4 ensemble-mean correlation (left) and debiased RPSS (right) for EC-Earth and System 3 five-member ensemble re-forecasts with May and November start dates over 1976-2005.



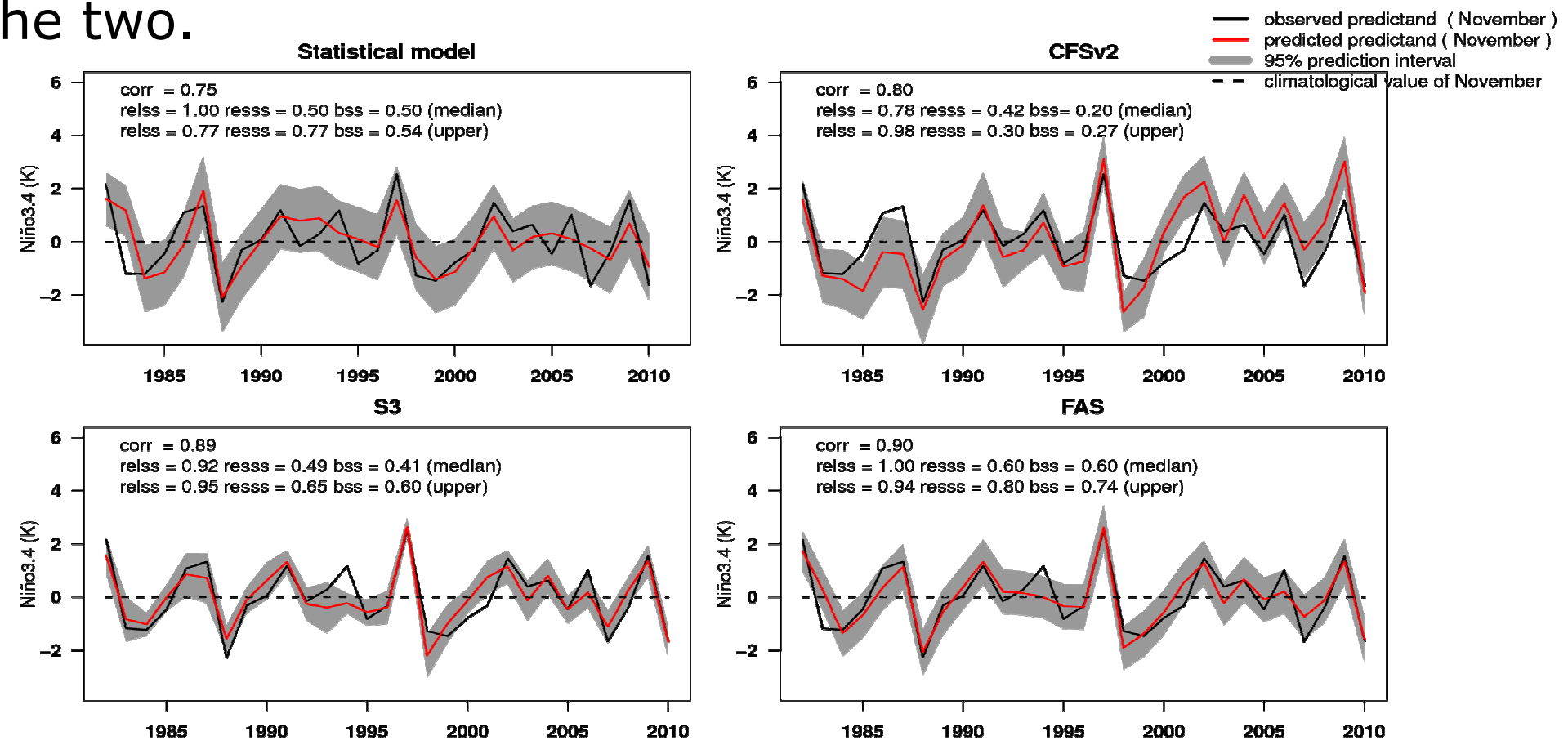
Calibration and combination

Forecast assimilation (Stephenson et al., 2005): y for observations and x for model output.



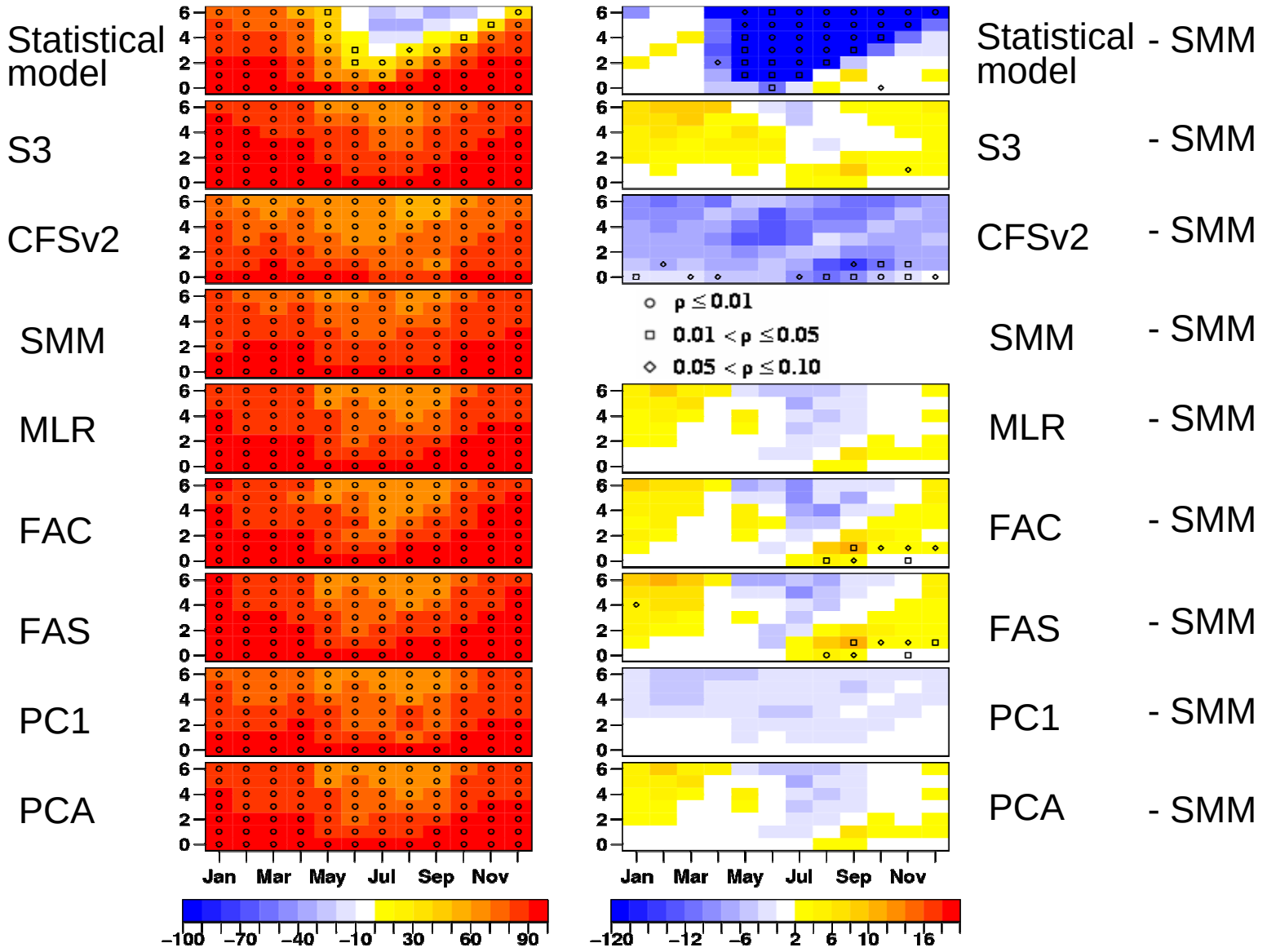
Multiple forecast systems available

Seasonal forecasts of November Niño3.4 ERSST (four-month lead) with a persistence-based statistical model, the ECMWF System 3 and CFSV2 forecast systems and the combination of the two.



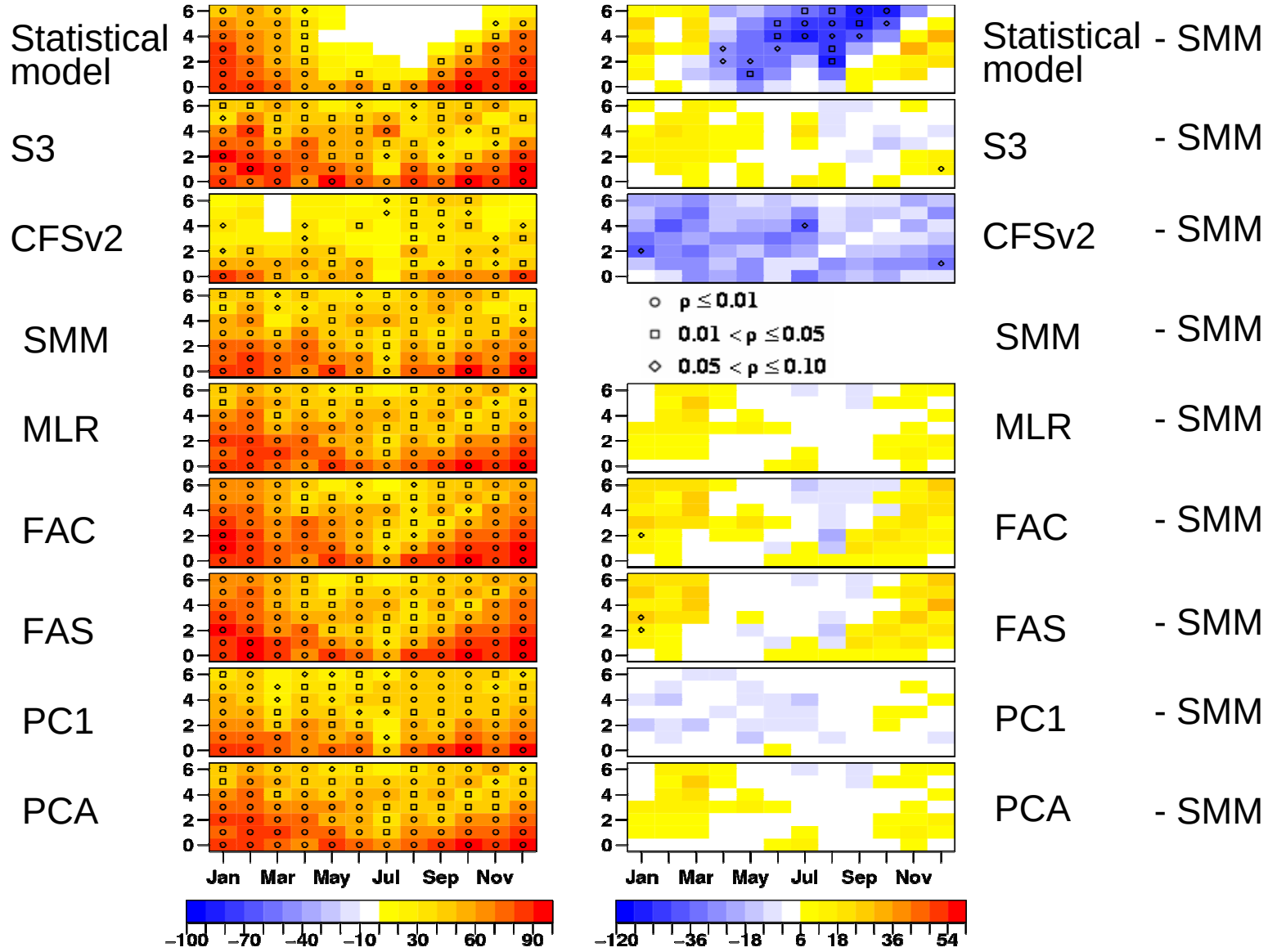
Forecast combination

Niño3.4 SST ensemble-mean correlation.



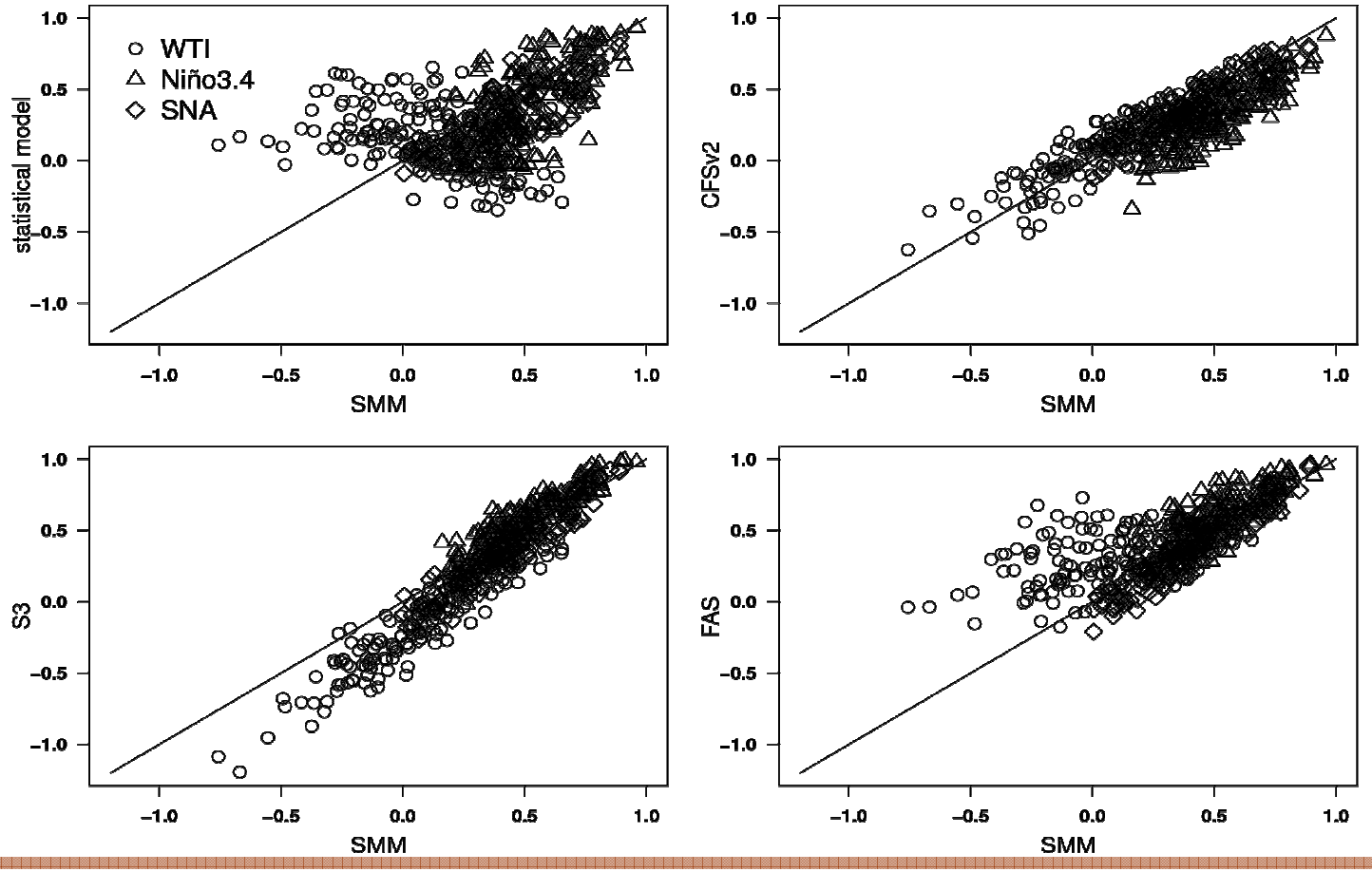
Forecast combination

Niño3.4 SST Brier skill score for probabilistic forecast of the event “anomalies above the median”.



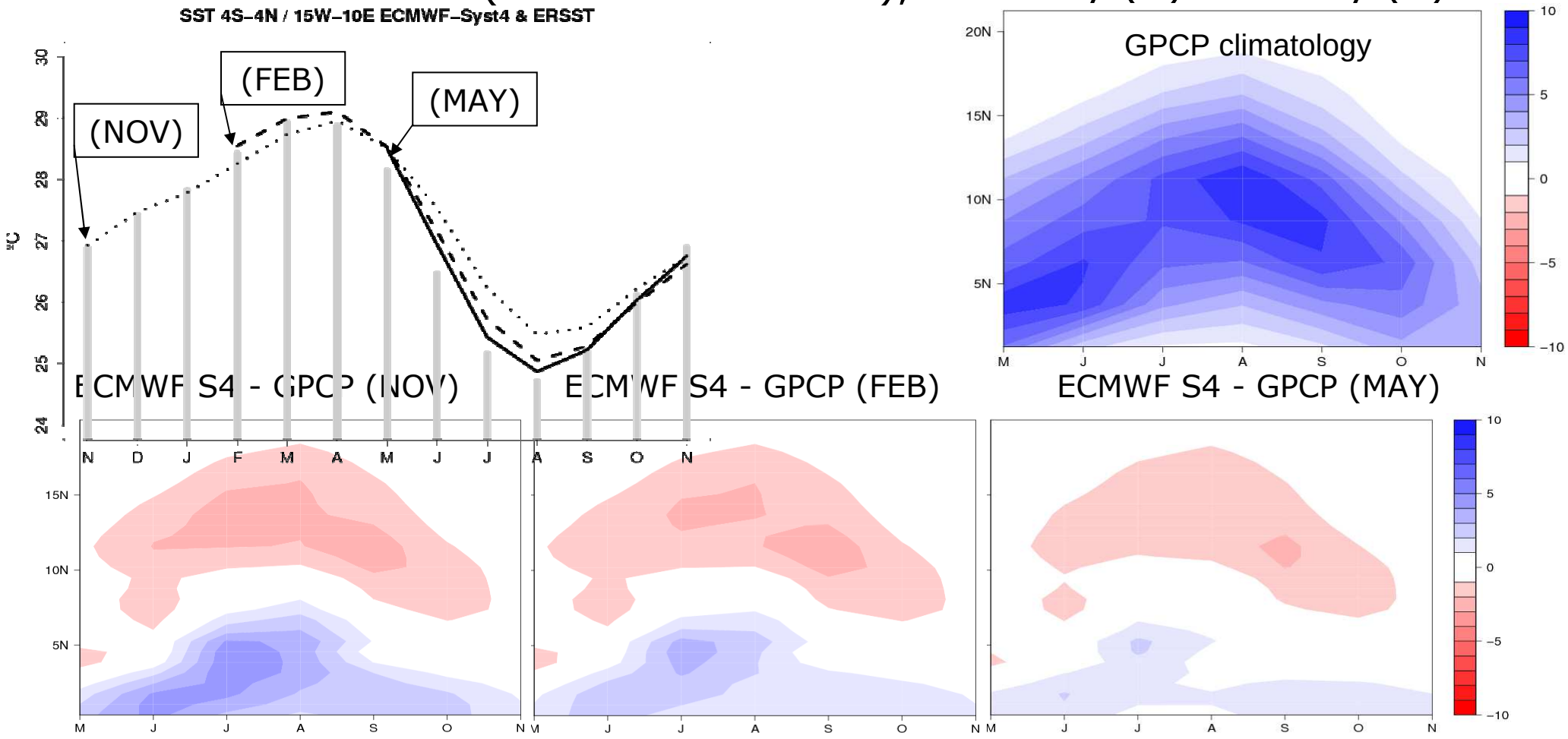
Forecast combination

Brier skill score for several forecast systems versus the simple multi-model for three SST indices (Niño3.4, West tropical Indian Ocean and subtropical North Atlantic), 12 target months, seven lead times and two events (above the median and upper tercile).



Systematic error: WAM

Averaged precipitation over 10ºW-10ºE for the period 1982-2008 for GPCP (climatology) and ECMWF System 4 (systematic error) with start dates of November (6-month lead time), February (3) and May (0).



Some thoughts

- Substantial systematic error, including lack of reliability, is still a fundamental problem in dynamical forecasting and forces *a posteriori* corrections. Forecast calibration such as forecast assimilation is still needed.
- There is statistically significant skill in ENSO and other tropical SSTs beyond the first few months of the forecasts.
- Dynamical forecast system improvements (in coupled model, initialization, ensemble generation) are needed, but also in empirical systems (for both benchmark and as independent systems) and in calibration and combination.